Voyager Mission Support

N. Fanelli and H. Nance
Control Center Operations

This is a continuation of the Deep Space Network Report on Tracking and Data Acquisition for Project Voyager. This article covers the period of December 1980 through March 1981.

I. Introduction

Voyager 1 completed the Saturn Post Encounter Phase of its prime mission operation and started the extended mission phase of operations.

Voyager 2 continued in the Jupiter–Saturn Cruise Phase with increased tracking in anticipation of the Saturn Encounter.

II. DSN Support

A. Voyager 1

The Post Encounter period was scheduled to end on 15 December 1980, but due to the unusual observations of the rings during the near encounter, the post encounter period was extended to 19 December 1980 so that another movie could be made.

1. Long time-base observation and system scans. The post encounter support consisted primarily of the observations of Saturn's atmosphere at high phase angles over a long-time base and periodic imaging of Saturn and system scans at phase angles and at latitudes different from those in the pre-encounter phases. Imaging data was returned at the higher data rates (29.8 and 44.8 kpbs) in the imaging formats. The system scan data was returned at the lower data rate (7.2 kpbs) in the general science format. Deep Space Stations (DSS) 14/12 and DSS 43/42 in the arrayed configuration were scheduled to receive the imaging data, with DSS 61 or 63 scheduled to receive the general science data consistent with station view period.

2. Saturn ring movie. The Saturn Rings movie activity was conducted on 18 December between Day of Year (DOY) 353 1012Z and DOY 354 0523Z. DSS 14/42/43/61/63 supported the activity with the DSS 61/63 and the DSS 42/43 complexes being in the array configuration to enhance the image data reception. This activity completed the Voyager 1 Saturn Encounter phase and the spacecraft entered the extended mission phase of activity.

B. Voyager 2

During the Post Encounter phase of the Voyager 1 mission operation, the activity of Voyager 2 was relatively quiet, with the majority of the tracking support being provided by the 26-meter network (DSS/11/44/62).

1. Navigation cycle. On 3–4 December 1980 a navigation cycle was conducted with Voyager 2. The Navigation cycle was supported by DSS 42/63/12. Software problems with the

Metric Data Assembly-Digitally Controlled Oscillator (MDA-DCO) interface required that the VGR-2 Navigation cycle support be conducted with a Programmed Oscillator Control Assembly (POCA) configuration. DSS 42 and 12 were, therefore, required to reconfigure with the POCA, vice the DCO, before their supporting passes. DSS 63 was configured with the POCA, so was not required to reconfigure for support. Near simultaneous ranging was conducted during the DSS 63/12 and DSS 12/42 overlap periods in addition to normal ranging. The Navigation cycle was completed successfully, with required data being delivered to the Project.

2. **Mini cruise science maneuver.** On 16 December (DOY 351 2213Z to DOY 352 0321Z) a mini cruise science maneuver was completed. The maneuver consisted of four yaw turns and four roll turns being accomplished, during which the spacecraft antenna was off earth point, therefore, no data were received. DSS 42 supported the activity that immediately preceded the maneuver with DSS 63 supporting the reacquisition activity. Playback reception of the data recorded by the spacecraft during the maneuver was supported by DSS 43 on 17 December (DOY 352).

3. **Trajectory correction maneuver.** On 26 February 1981 (DOY 057 2059-2246Z) a Trajectory Correction Maneuver (TCM-B7) was completed successfully. The objective of the maneuver was to place Voyager 2 on a more accurate trajectory to rendezvous with Saturn. The spacecraft was programmed to execute a negative roll turn followed by a negative yaw turn to align itself on a required burn vector. The TCM thrusters imparted a 0.574 meter/sec delta velocity after a burn duration of 215 seconds. The spacecraft returned to earth point by accomplishing complementary yaw and roll turns. The activity was supported by DSS 43 during the preparation phase and by DSS 63 during the actual maneuver. During the burn, the spacecraft was off earth point, no telemetry data were being received in real-time, but were being recorded aboard the spacecraft. The playback of the recorded data was accomplished during DSS 43's viewperiod the next day.

C. General

1. **Doubly differenced range.** In continuing effort to further refine tracking techniques to provide more precise spacecraft position information, the DSN is supporting doubly differenced range activity. The first activity supported occurred on DOY 355. This technique required that both DSS 61 and 12 track and range on Voyager 2, then, after a quick turn-around, track and range on Voyager 1. The turn-around from Voyager 2 to Voyager 1 was accomplished in 20 minutes. The stations were required to perform pre- and post-track calibrations on the ranging equipment for both spacecraft (S/C). This was a new requirement, as a station normally tracks only one S/C and performs the necessary pre- and post-track calibrations to support that one S/C. Although there were some problems in preparing for and executing the activity events, the results look promising. Another test was supported on DOY 031 (1981) by DSS 61 and 12. Fewer problems were experienced during this test and the results are being evaluated.

2. **Metric data assembly software.** Metric Data Assembly Software, DMK-5106-OP-F, which provides the capability to automatically control the Digitally Controlled Oscillator (DCO) and the uplink frequency required for tracking Voyager 2 started engineering testing at Goldstone on 6 January 1981. DCO implementation at the 34/64 meter stations was completed on 26 February 1981. After a series of Voyager demonstration tracks, during which problems were identified and corrected, a preliminary operational disk was provided. The Goldstone stations began Probationary Testing on 5 February 1981 with this disk supporting all projects. The software was also sent to the overseas stations where they began Probationary Testing on 16 February 1981. The software was transferred to operations on 2 March 1981 for an Operational Certification period by the stations prior to the official replacement of the previous operational support software. The software became the prime support software on 28 March 1981.

III. DSN Capabilities

A. Radio Science

The Saturn Near Encounter Radio Science activities for Voyager 2 will occur during the viewperiod of DSS 43. Since DSS 63 was the prime supporting station for the Voyager 1 Saturn Encounter Occultation Experiment, it was necessary to relocate the DSS 63 Radio Science equipment from DSS 63 to DSS 43. This equipment included the four channel narrow/medium band multi-mission receiver plus the backup wideband four channel multi-mission receiver and its associated digital recording assemblies. DSS 43 sent its two channel open loop receiver to DSS 63. This equipment relocation was accomplished during the month of January 1981. DSS 14 has the narrow/medium equipment comparable to DSS 43. Following successful installation of the equipment and subsequent system performance tests, a series of operational verification tests were conducted with the new equipment and an updated version of the Occultation Data Assembly (ODA) software. The checkout of the new software (DMO-5123-OP-C) was started over DSS 14 on 4 February, since their equipment was installed and operational at the time. Pioneer and Voyager X-band signals were used during this testing. The ODA OP-C testing started at DSS 43 on 19 February and at DSS 63 on 27 February. Only minor problems have been encountered;

the operational procedures are being refined and crew training accomplished during the testing. The software was transferred to operations on 16 March and tests will continue through August 1981 to ensure and maintain facility readiness. These tests will continue to use live spacecraft data and accomplish the functions of recording open loop data, playback of recorded data and on-site validation of recording quality, as will be required during the encounter.

B. Adaptive Tracking

The problems caused by the failure of the receivers on Voyager 2 (DSN Progress Report 42-49, Nov-Dec 1978) with the resultant 200 Hz bandpass in the operating receiver are complicated by spacecraft internal temperature changes. It has been determined that after various spacecraft activities, compartment temperatures rise and change the center frequency of the receiver bandpass and the rate of drift as the temperatures return to normal. Therefore, after these spacecraft activities, the Best Lock Frequency (BLF) is unknown and normally a command moratorium is declared, due to the uncertainty of establishing a proper uplink. During the Saturn Near Encounter, after the spacecraft comes out of occultation, this condition will exist, but it will be necessary to command the spacecraft sooner than a moratorium would allow. To provide background data on the frequency offset and to allow better estimates of the BLF after these activities, the DSN has been supporting special tracking procedures called "adaptive tracking and BLF determination". Essentially, after a spacecraft temperature change, the 34/64 meter station will accomplish the BLF determination sequence. This is a sequence of five predetermined ramps by the DCO through the estimated BLF. The data are analyzed in near-real-time to refine the BLF. The adaptive tracking sequence is exercised, during which the DSN is provided a frequency offset to "snap to", then to automatically ramp with the appropriate predicts. The frequency drift from the predicted is used to determine the new frequency offset, and used to keep the uplink centered in the receiver bandpass. This procedure is continued as long as necessary to ensure a proper uplink for commanding activities. This procedure relies on the DCO and the capabilities of the MDA S/W DMK-5106-OP-F automatic uplink feature.

C. DSS 12 Antenna Efficiency Improvement

DSS 12 was decommitted from support operations on 6 March 1981 and scheduled to become operational again on 24 April 1981. The purpose of the DSS 12 downtime is to improve the overall antenna efficiency.

The two outer rows of the primary antenna dish panels will be replaced and all panels reset. The subreflector surface tolerance will also be improved. This additional antenna work should improve overall antenna gain by at least 0.75 dB.

During the downtime, the subreflector controller will be modified and upgraded. New circuit boards and internal adjustments will provide improved antenna pointing accuracy, which will also improve overall antenna performance.

After the antenna work is completed, and prior to returning the station to operational support status, a series of star tracks will be performed to evaluate actual antenna gain improvement.